# Bluetooth Architecture Overview

Principal Engineer/Bluetooth SIG Chairman Mobile Computer Group Intel Corporation James Kardach



"The Bluetooth Specification is still preliminary; All information regarding Bluetooth is subject to change without notice"

#### Agenda

- Bluetooth SIG update
- Bluetooth architectural overview
- Summary/call to action

# What Does Bluetooth Wireless Technology Do

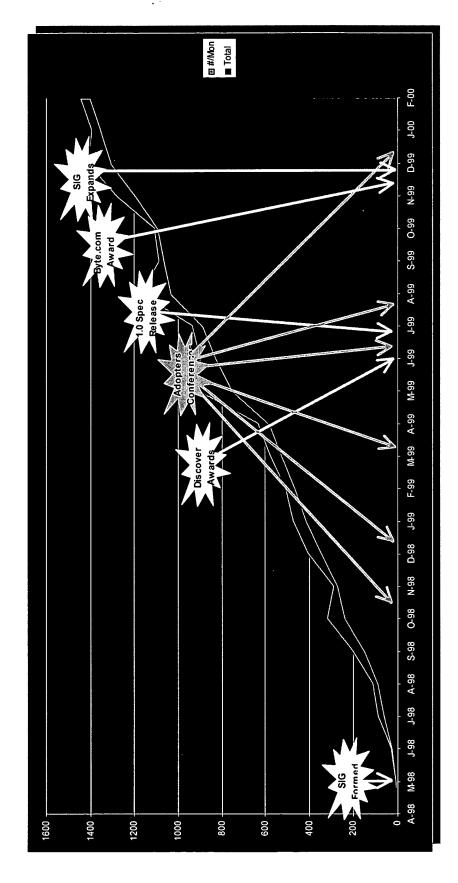
Replacement Cable 4 For You? **Access Points** Data/Voice

Personal Ad-hoc Networks

## Program Update

- Final specification published Monday 7/26/99
- Core technology specs and Profile requirements
- Result of work from ~200 engineers
- Bluetooth membership exceeds 1,600 companies!
- Bluetooth wireless technology becoming the choice for wireless connectivity
- Full list of member companies on Web site www.bluetooth.com
- Bluetooth program on track for products available in 2000
- Products available this year
- Next step is qualification program
- SIG now focusing on ensuring product interoperability
- Bluetooth qualification program started
- Bluetooth wireless technology is the basis for the IEEE 802.15.1 standard
- Bluetooth SIG has expanded
- New contracts and membership types

## Bluetooth Momentum



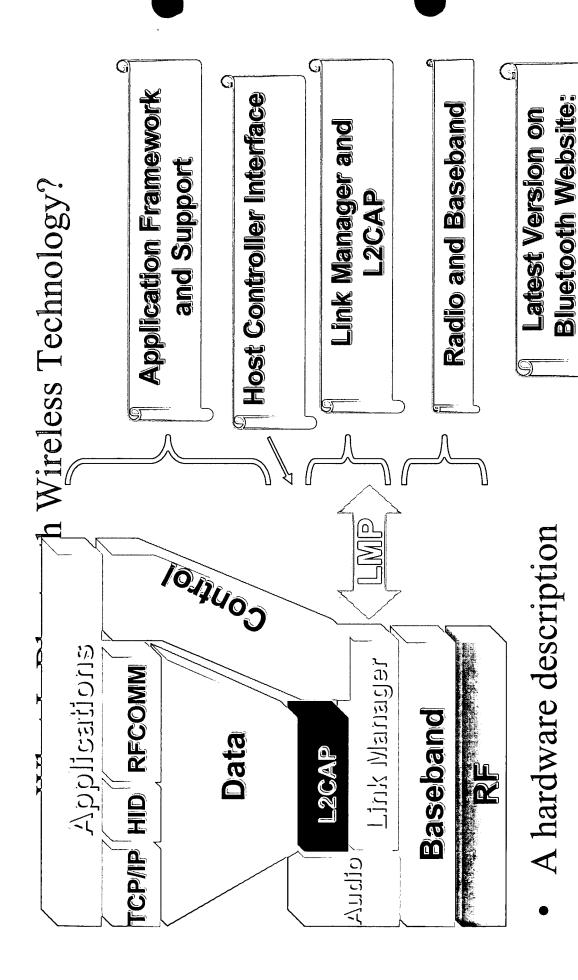
• SIG is still growing

#### The SIG Formally Known As Bluetooth; )

- New Contracts
- Adopter/Early Adopter = Early Adopter
- Early Adopter Contract
- Early Adopter in working group = Associate
- Early Adopter Contract, Associate Amendment
- Open IP license to Bluetooth wireless technology
- Original "Foundation Specifications"
- New technology in and around the 12 specification working groups
- Only need to sign 1 contract to use any Bluetooth wireless technology (the new one)

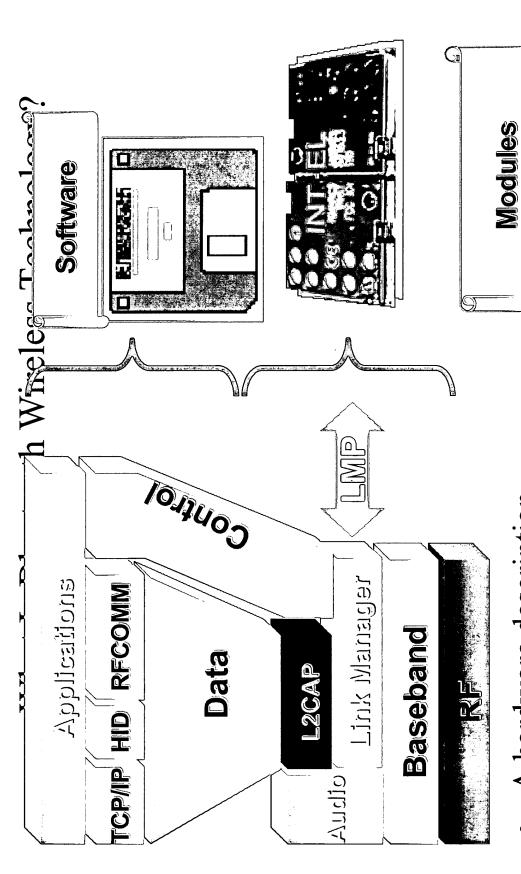
### Future Directions For Bluetooth **Profiles**

- Second generation radio
- ▶ Personal area networking
- ▶ In and around the car
- Wake-up,
- ▶ Human Interface Devices (HID)
- ▶ Audio/visual
- ► ISM interference/interoperability
- ▶ Printing
- ▶ Still image
- ► Extended Service Discovery protocols
- ▶ Local positioning

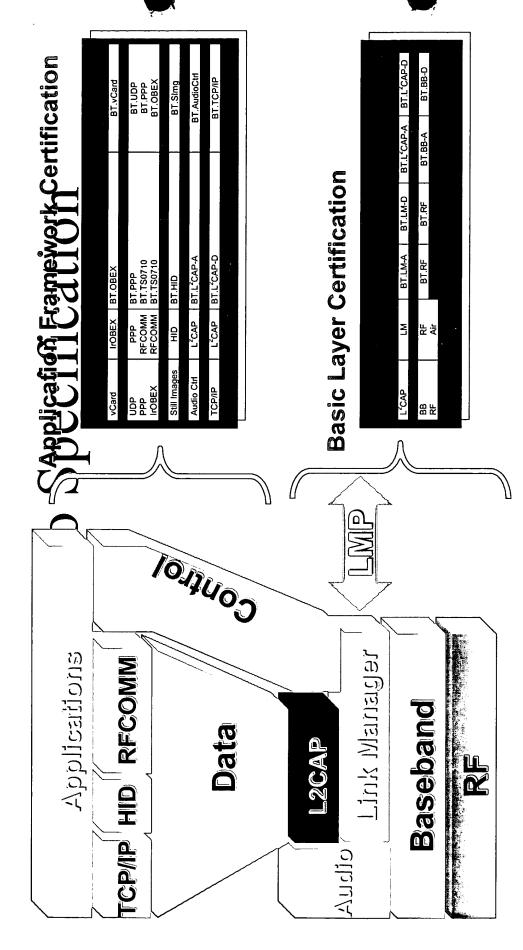


www.Bluetooth.com

An application framework



A hardware descriptionAn application framework



- Bluetooth devices will be tested against the specification
- Bluetooth Qualified Test Facilities (BQTF)

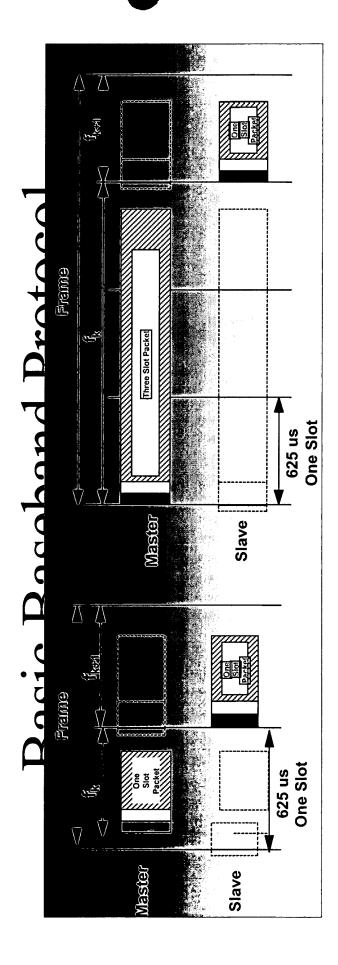


Topology	Supports up to 7 simultaneous links	Each link requires another cable
Flexibility	Goes through Walls, bodies, cloths	Line of sight or modified environment
Daria rate	1 MSPS, 720 간5ps	Varies with use and cost
Power	0.1 अशर्पेड बर्ध्यंथन कृष्णभन्द	0.05 watts active power or higher
Sizə/Wəight	$25~mm \times 13~mm \times 2~mm$ , several grams	Size is equal to range. Typically 1-2 meters. Weight varies with length
Cost	វ់កលែបប្រភព ទី១ ប្រមានក្រសួល	(ounces to pounds) ~ कुँउ -कुँ100/meter (end user cost)
रियोग्डीन	10 meters of Jess	শ্রোমন্ত্রভ ভব্যাহ্যা ৩০ হাস্ত্র, Typically 1 -2
Universal	og to regard man, red Intended to work anywhere in the world	metara Calbles vary With local customs
Security	Very, link layer security, ss radto	ଓଡ଼ୋମନ (ମିଟ ସ ସେଧିନ)

#### Cable Replacement

# Bluetooth RF Specifications

- Specified for low cost, single chip implementation
- Noise floor margin for substrate noise and low current LNA
- Linearity set by near-far problem
- In-band image allows low-cost low IF
- VCO phase noise enables integrated VCO
- TX-RX turn around time enables single synthesizer
- 2.4 ISM band chosen for global use and process capabilities
- Sensitivity traded for low-cost integration of transceiver and baseband

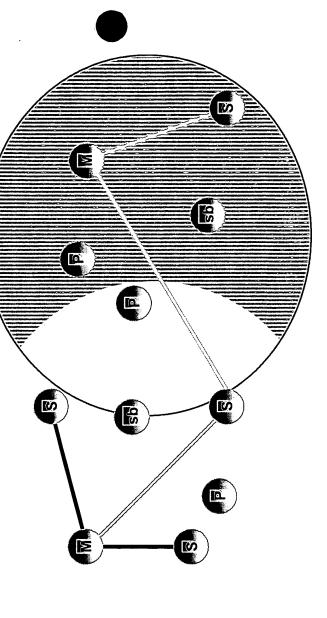


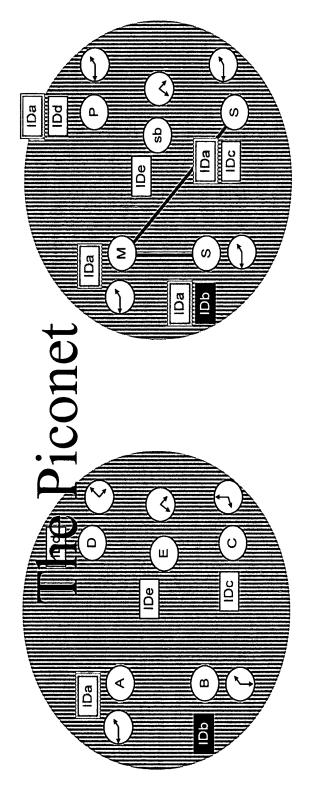
## Spread spectrum frequency hopping radio

- 79/23 one MHz channels
- Hops every packet
- Packets are 1, 3, or 5 slots long
- Frame consists of two packets
- Transmit followed by receive
- Nominally hops at 1600 times a second (1 slot packets)

## Network Topology

- Radio Designation
- Connected radios can be master or slave
- Radios are symmetric (same radio can be master or slave)
- Piconet
- Master can connect to 7 simultaneous or 200+ active slaves per piconet
- Each piconet has maximum capacity (1 MSPS)
- Unique hopping pattern/ID
- Scatternet
- High capacity system
- Minimal impact with up to 10 piconets within range
- Radios can share piconets!





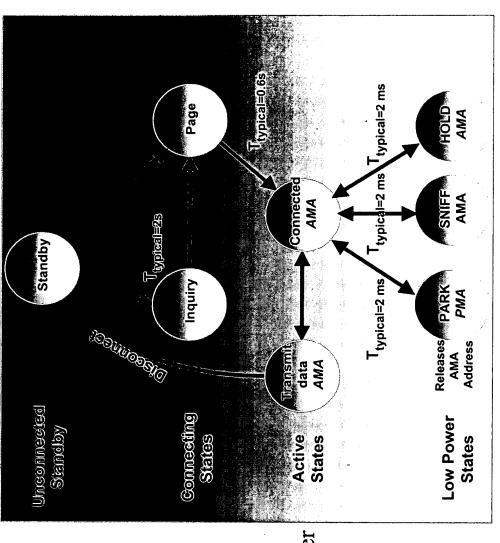
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- In forming a piconet, master gives slaves its clock and device ID
- Hopping pattern determined by device ID (48-bit)
  - Phase in hopping pattern determined by Clock
- Non-piconet devices are in standby
- conet Addressing  $\binom{M}{\circ}$  or  $\binom{S}{\circ}$  Active Member Address (AMA, 3-bits) Piconet Addressing
- Parked Member Address (PMA, 8-bits)



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## Functional Overview

- Standby
- Waiting to join a piconet
- Inquire
- Ask about radios to connect to
- Page
- Connect to a specific radio
- Connected
- Actively on a piconet (master or slave)
- Park/Hold/Sniff
- Low Powerconnected states

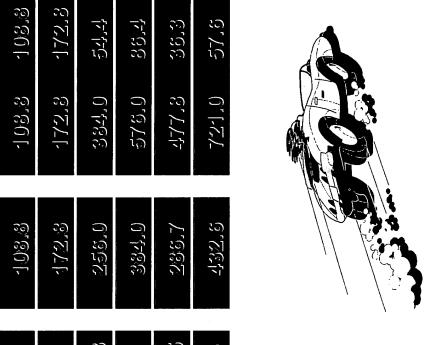


# Darket Tynes/Data Rates

asymmetric

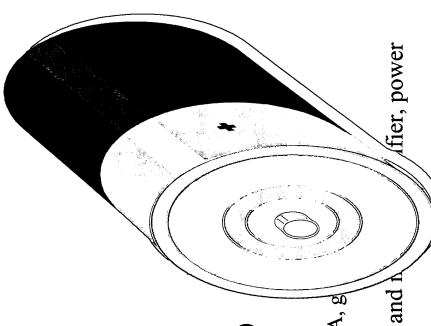
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	Packet	sket Types			Daria Partes (Mops)	$(\varepsilon \circ \circ )'$
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		177			0.458	576.0
01	6770 0111	1773 1773		SMC.	296.7	6.77t
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₹ <b>ට</b>	1990 1191				,	
77	1119		DINIS DHS			

- ASL -Packet like behavior
- SCO Circuit like behavior



## Mobile = Battery Life

- Low power consumption\*
- Standby current < 0.3 mA</li>
- b 3 months
- Voice mode 8-30 mA
- b 75 hours
- Data mode average 5 mA
- (0.3-30mA, 20 kbit/s, 25%)
- b 120 hours
- Low Power Architecture
- Programmable data length (else radio sleeps)
- Hold and Park modes 60 µA
- Devices connected but not participating
- Hold retains AMA address, Park releases AMA, g
- Device can participate within 2 ms
- \*Estimates calculated with 600 mAh battery and will vary with implementation







access code header

payload

## Forward-error correction (FEC)

- Headers are protected with 1/3 rate FEC and HEC
- Payloads may be FEC protected
- 1/3 rate: simple bit repetition (SCO packets only)
- 2/3 rate: (10,15) shortened Hamming code
- 3/3 rate: no FEC

## ARQ (ACL packets only)

- 16-bit CRC (CRC-CCITT) and 1-bit ACK/NACK
- 1-bit sequence number

# Bluetooth Security Features

Fast Frequency Hopping (79 channels)

Low Transmit Power (range <= 10m)

Authentication of remote device

Based on link key (128 Bit)

May be performed in both directions

Encryption of payload data

Stream cipher algorithm (≤ 128 Bit)

Affects all traffic on a link

Initialization

- PIN entry by user



# Application Level Security

- Builds on-top of link-level security
- Creates trusted device groups
- Security levels for services
- Authorization required
- Authentication required
- Encryption required
- Different or higher security requirements could be added:
- Personal authentication
- Higher security level
- Public key



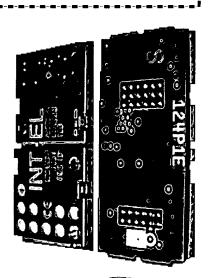
## Bluetooth Wireless Technology Is Global

- One version for the world
- Architecture compliant with global emission rules
  (2.4 GHz ISM band)
- Working through FCC, EC, MPT for spectrum, and power harmonization
- Architecture compliant and safe for use on airlines
- Working with FAA, JAA, FCC, airplane manufacturers, and airlines
- Reviewing security architecture with affected countries



# Bluetooth Radio Modules

- Complete radio on a module
- Designed to meet "Limited Module Compliance" (LMA) requirements
- Pre-certified to meet global regulatory requirements
- Allows devices assembled with modules to be "self-certified"
- USB Interface
- Solder-ball connections
- External Antennae

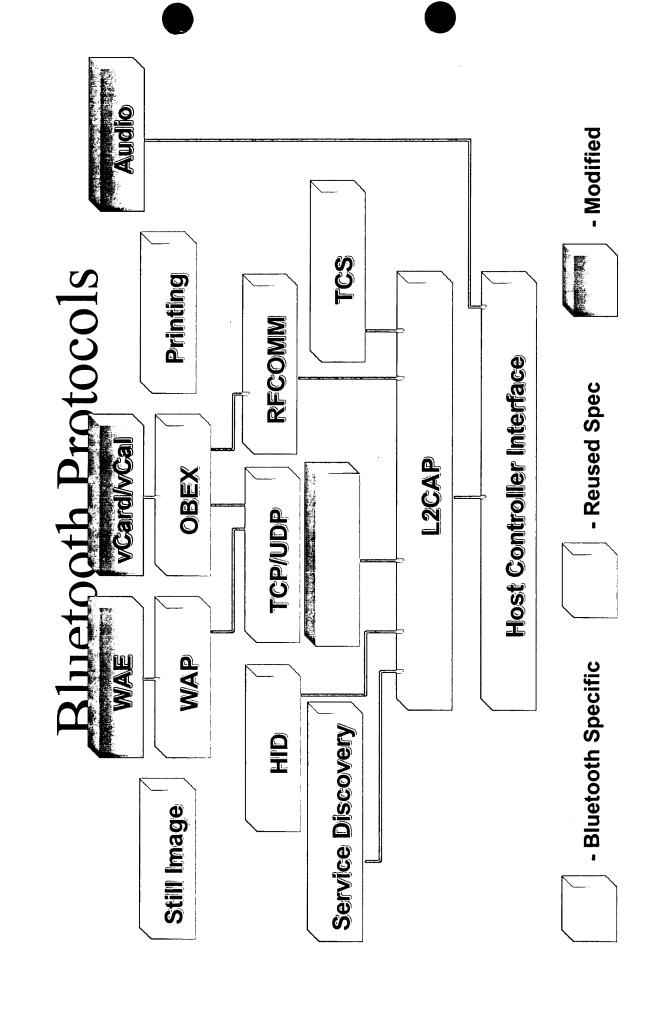


Compact FLASH Card

25 mm dia

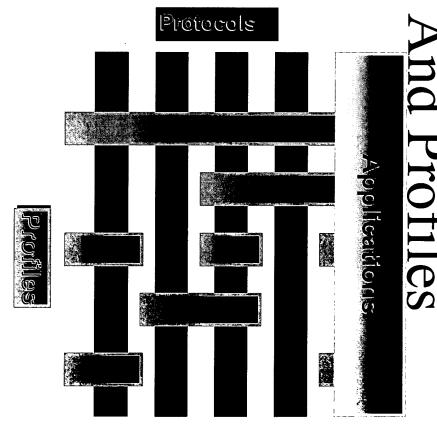
17x33mm

36x43mm



# Interoperability And Profiles

- Represents default solution for usage model
- Vertical slice through the protocol stack
- Basis for interoperability and logo requirements
- Each Bluetooth device supports one or more profiles



#### Summary

- technology and solution for portable, personal devices Bluetooth wireless technology is a global, RF-based (ISM: 2.4GHz band), short-range, connectivity
- It is not just a radio
- Create piconets on-the-fly (approximately 1Mbps)
- Piconets may overlap in time and space for high aggregate bandwidth
- The Bluetooth spec comprises
- A hardware and software protocol specification
- Usage case scenario profiles and interoperability requirements
- To learn more: http://www.bluetooth.com

### Call To Action

- Join the SIG if you haven't already
- Help advance Bluetooth functionality by supporting the working groups committees
- Got a new usage model? Submit a request
- Learn how Bluetooth wireless technology works NOW!
- See Microsoft's presentation on Bluetooth wireless technology
  - Big conference in Monte Carlo check it out!
- More information: http://www.Bluetooth.com
- Implement Bluetooth software and hardware in your products and systems
- Insure interoperability via Un-plugfests
- Help support native operating system development
- Provide test hardware to Microsoft

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2 🗀	Agenda
	Bluetooth SIG update
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	Summary/call to action
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4 🗀	Program Update
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- · Personal area networking
- · In and around the car
- · "Wake-up"
- · Human Interface Devices (HID)
- Audio/visual
- · ISM interference/interoperability
- Printing
- Still image
- · Extended Service Discovery protocols
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- UDI
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